Controlled Flow Studies for Fishability

Objective
Improve precision of estimated flow ranges for fishing by having a panel of users evaluate several known (usually controlled) flows. Generally applicable to rivers where historical fishing has adapted to an existing controlled flow regime and modifications of that regime are considered. Assembled panels may also provide opportunities to help roughly explore regional "supply" of similar rivers or "demand" for similar opportunities.

Typical approach
Similar to boating controlled flow assessments, Level 1 and 2 reports are used to determine flow range and opportunities of interest. Target flow increments are chosen and arranged for a short period of time (if possible). Anglers complete a pre-fieldwork survey on their experience and angling preferences, observe or fish the river at each flow (usually at a sample of locations), and evaluate flows and participate in a focus group after each flow. After all flows have been observed, participants make overall evaluations using a "flow comparison" format. Photos and video footage of key fishing areas and conditions can provide useful documentation.

Product
Summary of methods and findings in a report. Methods should include descriptions of panel and instrument development. Findings will typically include tables and graphs appropriate to the analysis. Appendices typically include a participant list, focus group notes, photo gallery, and survey instruments. Video or photographic documentation may supplement report information.

Responsibilities
These studies are more complicated and typically require substantial participation by utilities, their consultants, agencies, and stakeholders. Utilities (or their consultants) have primary responsibility, but agencies and stakeholders also play important roles (see sidebar with more detail on these roles).

Additional issues
In addition to issues for boating controlled flow studies, fishability studies have other complexities.

Representativeness of the panel may be particularly important because anglers who fish for certain species or use certain techniques may be poor evaluators of flows for other species or types of fishing (e.g., wading-based trout angling with flies vs. boat-based salmon fishing with bait). This requires close coordination with stakeholder groups to represent target opportunities.

Anglers can evaluate specific locations as a group at each flow, or independently decide which locations to assess (which might change at different flows). There are advantages and disadvantages of each strategy, depending on the length of the reach, homogeneity of its physical characteristics, and the time anglers will have to assess flows.

Cautions & limitations
As with boating controlled flow studies, fishability studies are most useful where river segments are short, flows can be definitively controlled, river access is easy, and anglers will participate.

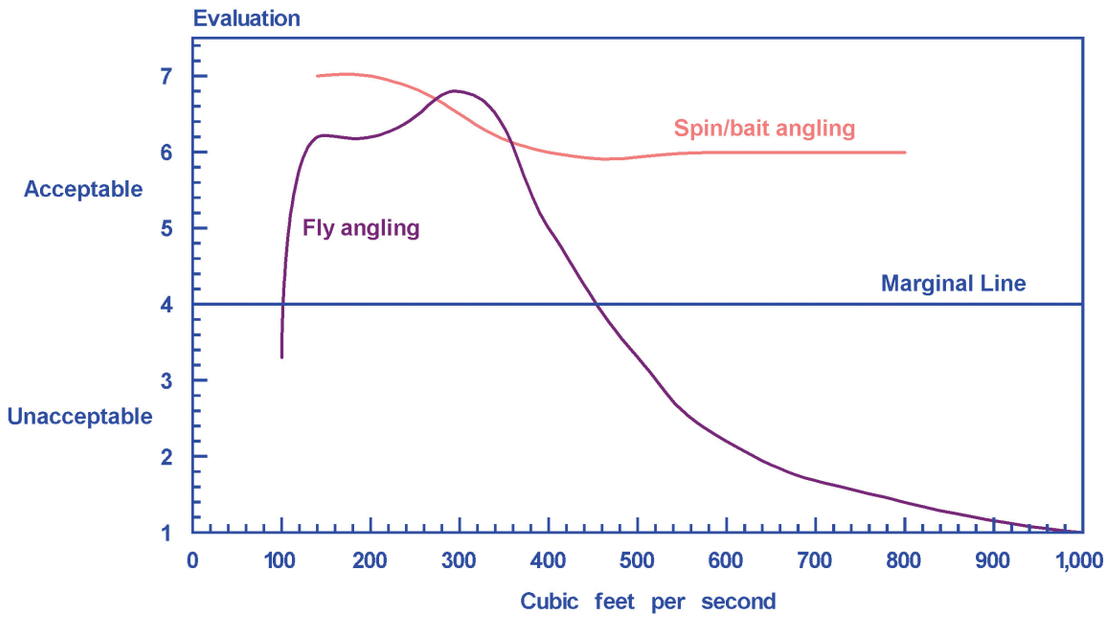
Fishability studies are only one component of assessing flow needs for fishing opportunities. Fishability studies focus on access to fishable water, offering less information about long term effects on fishing success, the fishery, or biophysical conditions (see separate sidebar on these distinctions).

Left: Anglers evaluated a different flow each day during a fishability study on California's Pit River. At the end of the multi-day study, a "close-out" survey compared all the flows.

Wadeability is critical for some types of angling, but depths and velocities also affect tackle and technique choices. Higher flows require heavier tackle to reach fish that are "holding" lower in the river, but this increases the risk of snagging. Right: Idaho's Salmon River.

California's Pit 4 bypass reach has Project-induced base flows of 150 cfs, allowing anglers to cross the river and fish away from encroaching vegetation. The 420 cfs study flow (left) made wading and crossing difficult, dramatically reducing "fishable water."

Angling flow evalution curves for California's Pit 4 reach. Optimal flows for wading-based fly fishing are between 150 and 350 cfs. with a sharp decline at higher flows. In contrast, spin/bait angling was good at all study flows because it doesn't require wading.



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Flows, Fish Habitat, and Fishability

High quality fishing obviously starts with good habitat and a healthy fishery, but these may not be sufficient. For some anglers, catching fish may be less important than broader experiential benefits such as "exploration," "experiencing natural environments" or the "challenge of fishing" (Knopf et al. 1973; Fedler and Ditton 1994). A "blue ribbon" fly-fishing stream, for example, has a good fishery and good water to fish (e.g. wadeable access to riffles and pocket water, sufficient casting space away from riparian vegetation, and non-turbid water). While anglers appear able to adapt to different flow conditions, they often have preferences for specific conditions and fishing techniques (Whittaker et al. 1993); these can be affected by changes in flow that anglers can help evaluate.

"Fishability" studies have been developed to address this issue, and they have become important in some relicensing efforts where licensees and stakeholders consider changes in flow regimes, whether for boating, habitat, or other values. Value judgments about choices of recreation outputs require good information about impacts on all resources.

In conducting fishability studies, it is important to separate evaluations of "angler habitat" from evaluations of "fish habitat," and it is clear that these habitats may not be equivalent. Flows that optimize high quality angler habitat may sacrifice fish habitat, just as flows that maximize numbers of target fish species may sacrifice important elements of anglers' experiences. For example, would wading-based fly anglers prefer higher catch rates or larger fish if it required fishing from a boat or using spinning gear? Would anglers prefer "easier" fishing conditions (e.g. wadeable low flows where fish are concentrated) to those that are "harder," even if harder conditions increase the number or size of fish by a certain amount?

Fishability studies only address immediate effects that anglers can evaluate; they do not provide information about immediate or long-term biophysical effects. Anglers in fishability studies consistently note concerns about flow effects on fish populations, feeding behavior, spawning success, and the overall health of the fishery. However, most anglers are not the appropriate "experts" to assess these impacts. We suggest that the best way to prevent these biophysical concerns from confounding fishability evaluations is to discuss them in a pre-evaluation focus group. This gets these issues "out on the table" and allows anglers to voice their opinions, but then narrows the focus to attributes anglers are best equipped to evaluate: access to fishable water (wading, from the bank, or by boat) and use of fishable water (tackle and technique considerations).

It is difficult to evaluate fishing success at different flows during a controlled flow effort if study flows are provided for only a few hours. Most anglers develop evaluations of fishing conditions over multiple visits that vary where they fish or the tackle and techniques they use, as well as larger factors such as weather, season, time of day, and availability of a hatch. In addition, fish may not have "adjusted" to study flows, so anglers don't know if fish are behaving as they would over the long term.

Fishability studies also need to carefully specify the type of fishing opportunity under consideration; in some relicensing efforts, the choice may be between different types of angling rather than more subtle changes in one type. Even on the same river, for example, boating-based fishing for salmon may have flow needs substantially different from wading-based fly angling for trout. It is also important to recognize that anglers may be "committed" to a certain type of fishing associated with a particular flow regime. New flows may change the type of fishing, and anglers may not want to "lose" the old

In fishability studies, anglers evaluate important attributes such as wadeability and access to fishable water.

Right: Wading "experiments" during a study on California's Upper North Fork Feather River showed differences in individuals' "willingness to wade," but the controlled flow study showed general agreement about the flows that produced high quality fishing conditions.

opportunity. Well-designed fishability studies can address these different opportunities and evaluations, but may require more care in developing evaluation panels and focusing on appropriate variables.

Integrating fish habitat and fishability information is also complex. As discussed in the conceptual framework (Figure 1), tradeoffs among resource outputs are related to resource conditions that may change over time. But one should not assume that the choices are to provide for one or the other (not both). There may well be "elegant" solutions where flow regimes provide critical fishery benefits at some times and optimize fishability at others. In all cases, good fisheries management requires consideration of the full range of social and biophysical outputs and their potential trade-offs (Ditton 2004).

Social scientists have begun developing models for assessing complex tradeoffs inherent in fisheries management decisions (Aas et al. 2000; Gillis and Ditton 2002), but none have been applied to flow issues. Social science can help determine anglers' preferences for different types of fishing opportunities affected by flows. However, the opportunities must be carefully specified with both social and biophysical information. Preferences will probably shift depending upon 1) the abundance, size, and distribution of the current versus "new" fishery; 2) whether the new fishery will include new species (e.g. salmon and/or steelhead); 3) how new species might affect existing species; 4) relationships between flow regimes and fishing success; and 5) how flow regimes would affect the way anglers fish (technique and tackle, and whether it was boat, shore, or wading-based). To assess angler preferences, biophysical scientists need to specify how flow regimes affect the fishery and social scientists need to develop data from anglers to consider the trade-offs. This is an area for truly interdisciplinary work.

In "angler habitat" or fishability studies, it is critical to carefully define the type of fishing (species, tackle type, and technique), just as fish habitat studies assess needs for different species and life stages. For example, king salmon (left inset) and sturgeon (right inset) fishing are relatively "flow-insensitive" because anglers often fish from boats in deeper water using bait or heavy spinning gear. Wading-based fly fishing for trout (bottom) is more "flow-sensitive" and has a narrower "fishable range."

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Roles and Responsibilities During Controlled Flow Studies

The following is a list of typical tasks during a controlled flow study (for boating, fishability, or aesthetics), along with typical roles and responsibilities. These tasks may also apply in multiple flow reconnaissance efforts. The list may offer a good starting point for agreements during a study, but negotiations and flexibility are possible. Depending upon the skills, experience, and resources of utilities, their consultants, agencies, or stakeholder groups, there may be efficiencies in "trading" tasks.

Providing flows
Utilities are usually responsible for controlled flow releases (when feasible), although these may need to be coordinated with other agencies or water administrators. Complexities here should not be underestimated; there may be technical, administrative, or legal challenges in scheduling and then achieving target flows (or capitalizing on natural variation). It is particularly important for researchers and utility relicensing staff to work closely with project operations staff; these on-the-ground staff know whether requested flows are possible, and they will ultimately be the ones responsible for providing them. Additional coordination may also be necessary with researchers from other resource areas that would like to capitalize on the availability of controlled flows. Early interdisciplinary communications to identify and coordinate goals may pay dividends.

Flow measurement / development of flow models
Some reaches may not have existing gages, so flow measurements to ensure accurate knowledge of controlled flows are important. Coordination between agencies and the utility may suggest roles, but ultimately the utility is responsible for ensuring this task is completed. USGS or state water resource agencies may offer other options. In the case of new licenses, the development of hydrology models may be necessary to allow studies to capitalize on natural variation.

Panel development and organizing participants
Stakeholders for boating or fishing "communities" may be able to provide names or organize groups for the study, although consultants sometimes assume this role. Depending upon the size of the panel and the number of flows to be evaluated, this task can be considerable (especially for studies that are conducted with intervals between flows). Agencies and utilities generally review lists to ensure representativeness for each opportunity of interest.

Safety plan
Utilities usually develop a safety plan in collaboration with participants and the stakeholder requesting the study. Although there may be exceptions for particularly challenging reaches, safety plans are typically only a few pages long. Contents typically cover equipment and skill expectations for participants, communications equipment provided by the utility, communication and rescue protocols, and lists

Safety is always important during fieldwork. Safety plans identify potential problems and ensure that equipment and expertise are available during a study.

Left: Boaters on Oregon's Clackamas River were able to quickly free this raft using commonly-carried safety gear.

It is important to know flows during a study. Releases from dams are seldom precise, so accurate gages or field measurements (right) may be necessary.

Stakeholder participation helps ensure study success.

Left : Forest Service staff discussing conditions during the Pit River boating study.

of authorities to notify about the study. Safety plans do not usually describe protocols for addressing specific rescue situations at specific locations.

Liability waivers
Utility lawyers usually develop these forms; consultants and stakeholders usually review them. All participants are typically required to complete them during assessments or other fieldwork.

Survey instruments
Consultants usually develop the survey instruments; utilities, agencies, and stakeholders usually review them.

Liaison with the public or other users
The utility is usually responsible for informing other users of flow changes during a study. In some cases, restricting other uses during the study may be necessary to reduce risks. If media interest is high, some opportunity to exchange information between researchers, participants, and the media may be arranged.

Logistics
There are several tasks possible in this "catch-all" category, including shuttle/ transportation logistics, locations for meetings, meals and snacks for participants, access, coordinating public or media interest, coordination with local search and rescue organizations, camping or accommodation for participants during a longer study, and so on.

In general, the utility or its consultants are responsible for organizing and supporting these tasks, although coordination with agencies and stakeholders may suggest efficiencies or cost-savings. Most utilities provide shuttles and lunches/snacks during studies, but not all provide accommodation, pay travel costs (mileage), or cover evening meals.

Surveys provide quantitative data and focus groups add qualitative information, but effectively organizing, conducting, and documenting these data collection efforts requires skill and care.

Above: Boaters complete surveys (inset) and participate in a focus group during a controlled flow study on California's Kern River.

Supply and Demand Assessments

Objective
More precisely describe regional availability of similar recreation opportunities (supply), regional demand for opportunities, or likely use levels if new opportunities were to be created by project enhancements. Regional supply and demand information can be helpful for deciding the scale or extent of potential enhancements.

Typical approach
Level 1 and 2 efforts commonly list regional recreation opportunities to provide context for more focused flow-recreation studies. Similarly, information from interviews, focus groups, and surveys can help identify lists of "substitute" opportunities, demand for certain types of opportunities, comparative ratings among different river reaches, or likelihood of use. This Level 3 effort involves more comprehensive assessments that integrate multiple sources of information. Supply studies develop a database of regional river segments and characteristics; analyses can quantify the number of segments that meet specific criteria (e.g., Class IV boating segments within 3 hours of city X), or describe reaches that meet those criteria. Demand studies also integrate multiple sources (e.g., national, state, or regional participation surveys; regional equipment sales; estimates from recreation leaders) to predict participation and trends. In some cases, this information may be used to help estimate use levels for specific recreation opportunities. Surveys of regional groups (e.g., local anglers) are another option that may make sense if potential project effects include the development of a new resource (e.g., a restored salmon fishery).

Product
Summary report of supply, existing or projected demand, and estimates of use. The report includes descriptions of methods, sources and their limitations, and findings.

Responsibilities
These studies are led by utilities or their consultants. Agencies and stakeholders may participate in reviewing supply database variables, suggesting potential demand assessment sources, reviewing surveys, or reviewing draft reports.

Additional issues
These studies require integrating several sources of information, each with limitations or assumptions of varying certainty. Quality assessments will clearly identify sources, limitations, assumptions, and how information is combined to form conclusions.

Cautions & limitations
Assessments of existing regional opportunities (supply) can be quite accurate, depending upon the resources available for the development of a database and the quality of analysis. Analyzing basic guidebook information can provide useful summaries of nearby opportunities and help assess how a

Some recreation activities are extremely popular, creating crowding or competition. Demand and supply assessments attempt to predict future use levels, which is challenging even with good information.

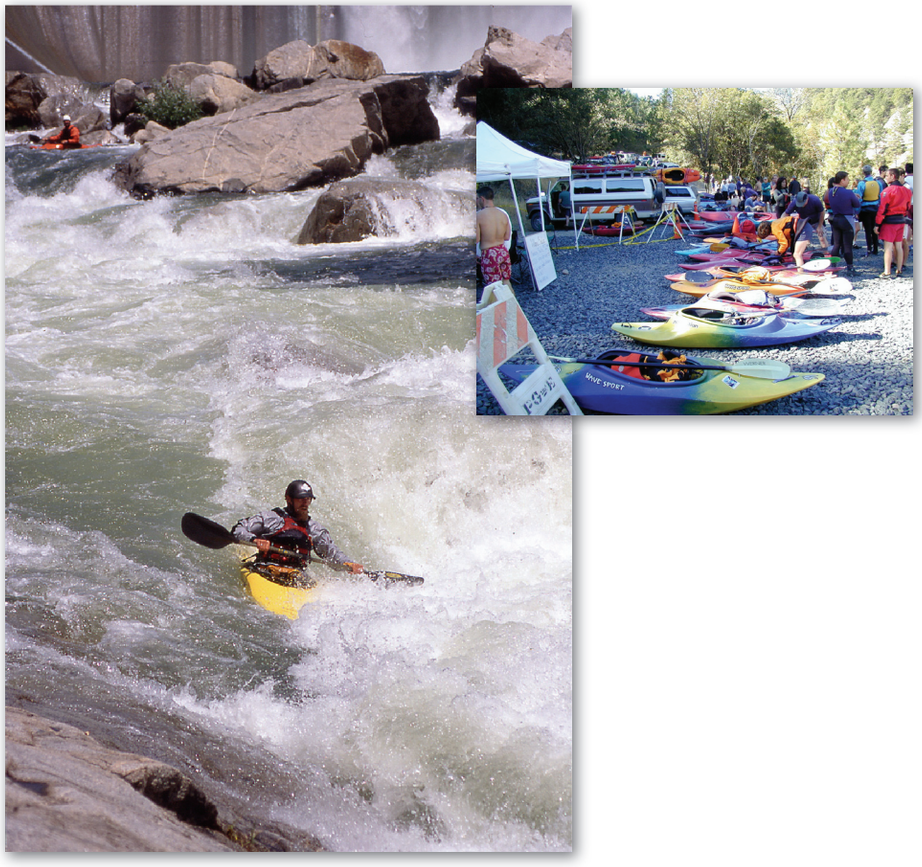
Left: "Combat fishing" for sockeye (red) salmon on Alaska's Upper Kenai River.

proposed enhancement might increase regional supply. However, "list-oriented" assessments usually do not provide sufficient information. Although research on substitution is sparse, there are complexities in how recreation users consider and compare substitute resources and activities (Brunson and Shelby, 1993).

Assessments of demand or estimates of use are even more challenging, particularly when they are intended to apply thirty to fifty years into the future. Recreation participation in specific activity categories is not always stable or predictable, and new activities develop over time. Other factors such as population growth and demographic trends, economic trends, new technologies, and age and the "participation cycle" also affect recreation participation and confound easy predictions. These complexities don't mean assessments are worthless, but their limits should be acknowledged.

Demand or supply assessments provide context for utilities, agencies, and stakeholders to consider the relative value of existing or potential recreation opportunities and associated mitigation or enhancement measures. However, their limitations (see above) can be substantial, and the scarcity or abundance of regional opportunities or potential users are not the only criteria for protecting, enhancing, or mitigating recreation opportunities.

The popularity of "playboating" has made kayaking a rapidly growing river sport. Above: Oregon's Clackamas River.



Relicensing sometimes produces a new "supply" of recreation opportunities. The number of boaters (far right) using whitewater flows on the North Fork Feather River (right) exceeded most predictions, creating management issues that demand studies help anticipate.

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Study Needs for "New" License Applications

Most of this document focuses on study options for rivers where flows are already regulated (e.g., FERC re-licensing projects, water rights adjudications, or reviews of dam operations). When applied to "new" (as yet unbuilt) hydropower projects, researchers and others may find several additional challenges.

- New hydropower projects are generally proposed for currently unregulated rivers, so impacts are potentially greater than for an existing project (where decisions are limited to alternative operation scenarios). Advocates may argue for higher standards defining "acceptable" impacts because new projects are "irreversible." This suggests studies with Level 3 precision, but this may be challenging for a variety of reasons (discussed below).

- New projects may have limited hydrology information, with insufficient data to assess wet, dry, and normal years with and without the project. Hydrology modeling is the usual solution to this problem (typically applying information from a nearby drainage), but these models are generally less precise.

- Rivers with proposed projects may be in relatively remote or limited access areas, with little history of recreation use. Recreation opportunities may not be well-known or described in guidebooks or other literature, and studies are more speculative (e.g., anticipating how changed access from a new project might induce new use).

- Remote or limited access areas complicate logistics and the ability to involve recreation users in studies (as members of reconnaissance-based assessments, participants in multiple flow assessments, or interviewees for flow comparison surveys).

- Because flows are generally unregulated, a common study option is a multiple-flow assessment that capitalizes on natural flow variation. However, this can be challenging when compounded with limited hydrology information, limited access, and limited users – particularly in a two year study period prescribed by FERC rules.

- Flow-recreation studies for projects with these kinds of constraints may be limited to reconnaissance-based, expert judgment methods (Whittaker et al., 1993, p. 59). Compared to other methods that involve users and more precise hydrology information, it is even more important that researchers have experience with the types of river recreation at issue.

- Long-term impacts on vegetation, geomorphology, or aquatic and terrestrial species are likely to play a larger role for new projects. Many long term impacts from regulated flow regimes have already occurred by the time of relicensing, and the choices for studying additional impacts due to operations choices are more limited. With a new project, the magnitude of change is likely to be larger but the ability to predict effects is more limited (especially in a two year study period). Researchers may resort to qualitative descriptions of alternative outcomes by referring to existing literature from other rivers, recognizing that applicability to new situations will be less precise.

- Estimating demand for recreation on rivers with new projects is particularly problematic if access is limited. In general, the farther a river is from population centers, the more difficult it will be to estimate demand – especially for longer planning horizons common in licensing (50 years). As an illustration, population levels in small Rocky Mountain towns (e.g., Vail, Telluride) in 1960 were small and about 1% of the national population participated in winter downhill activities such as skiing. Nearly 50 years later, amenity-based economies anchored by ski area development have created "boom towns," about 15% of a much larger national population now ski or snowboard, and considerable societal resources are dedicated to ski industry infrastructure. The point is that predicting use over long planning horizons can be very challenging, particularly for areas where access has been limited in the past.

- Finally, new projects may need to consider trade-offs of losing wilderness/primitive recreation opportunities to less primitive opportunities on regulated, more accessible rivers. Studies that assess these trade-offs may require assessments of potential use, existence, option, and bequest values through "travel cost" or "contingent valuation" studies. These types of economic studies are beyond the scope of this document, but there is a substantial literature on recreation valuation that may apply to new hydropower proposals (Loomis and Walsh, 1997).

Remote rivers are likely to have limited hydrology data, poor information about recreation use, and challenging logistics for conducting studies.

Above: Alaska's Talkeetna River has fly-in access, no permits or use information, and a gage distant from the whitewater segment.

New water projects are particularly challenging to study because development and recreation use will change substantially, and predictions of supply and demand are speculative.

Right: Upper falls on Falls Creek bordering Alaska's Glacier Bay National Park at 80 cfs. A licensed but unbuilt hydroelectric project would improve access to the falls and increase visitation, but reduced flows may decrease aesthetic value.